SPECTRUM

ISTA

Summer 2014, Vol. 40, No. 1

The Journal of the Illinois Science Teachers Association

In this Issue: **Reconnecting STEM and ROOTS**
Illinois Annual Trade Book Reading List
Scientists in the Classroom
Promoting Conceptual Change of Preservice Teachers

Plan Ahead:
Science in the South - November 7 - 8, 2014 at Southern Illinois University at Carbondale
NSTA National Conference on Science Education - March 12 - 15, 2015 in Chicago, Illinois

Illinois Science Teachers Association

Spectrum

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Volume 40, Number 1

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Send submissions and inquiries to the editor. Articles should be directed to individual area focus editors (see next page and *write for the SPECTRUM information).*

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Cover: Educators engaged in hands-on learning at IMSA's Multi-County Professional Development Day. Photo courtesy of IMSA Media Services.

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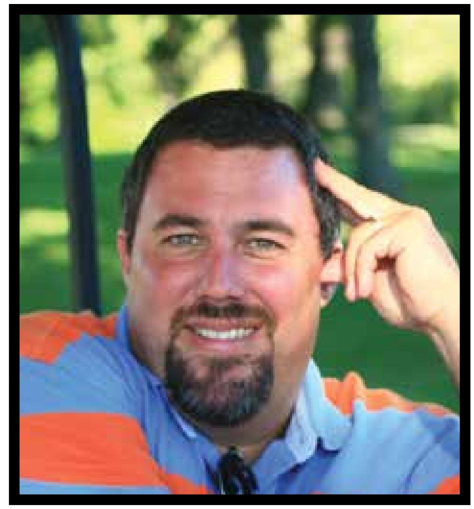
Table of Contents

ISTA News

President's Corner

Paul Ritter



It is Summer Time….

Great job this year to you, Team ISTA. Each of you deserves a much needed break from all of the crazy things the school year brings. I hope you've been spending time with your family and friends, re-energizing yourself for the coming school year. As usual my summer is completely booked up with projects. This year begins with dual credit teacher training, and then my second year of Next Generation Science Standards training. Following that, I am taking a week to work with the amazing people of the Sun Foundation during their Art and Science program which bring 460 plus kids into the woods to do real world projects. It is an amazing education and I could not be more thankful to just be a part of it. Your regional directors and board members are also hard at work for our association. Recently, we had our ISTA full board meeting at Brookfield Zoo. The Zoo has an amazing facility. During that meeting we had presentations from Wayne Talbot of Cambridge, England about the evolution of science education globally, and conservation and science education at Brookfield Zoo with Lanis Petrik, manager of Teacher Programs. Also discussed at the meeting was a new initiative (from ISTA vice president Jason Crean, treasurer Bob Wolfe, and regional director Courtney Stone) to provide regional workshops to help prepare for the new Next Generation Science Standards. As soon as we have more information on this initiative we will send it out to you on the ISTA list serve. To compliment this endeavor ISTA secretary Kendra Carroll is working with a team to establish the ISTA Career Development Bureau. New positions to the ISTA team this year are Tom Roose as Director of Membership, Larry McPheron as Director of Marketing, Director of Informal Education Lindsey Snyder, and Assistant Executive Director for Outreach and Initiatives Gwen Pollock. With the addition of these new positions ISTA will be able to provide more educational opportunities for you in your respective grade levels. We are very excited about what the future holds for ISTA and science education in Illinois and thankful to have you on the team.

Have a great summer.

Yours for education,

Paul

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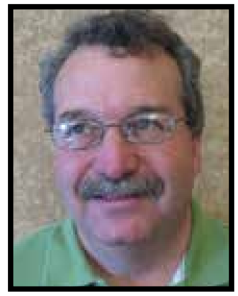
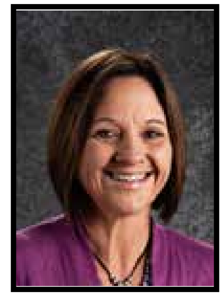

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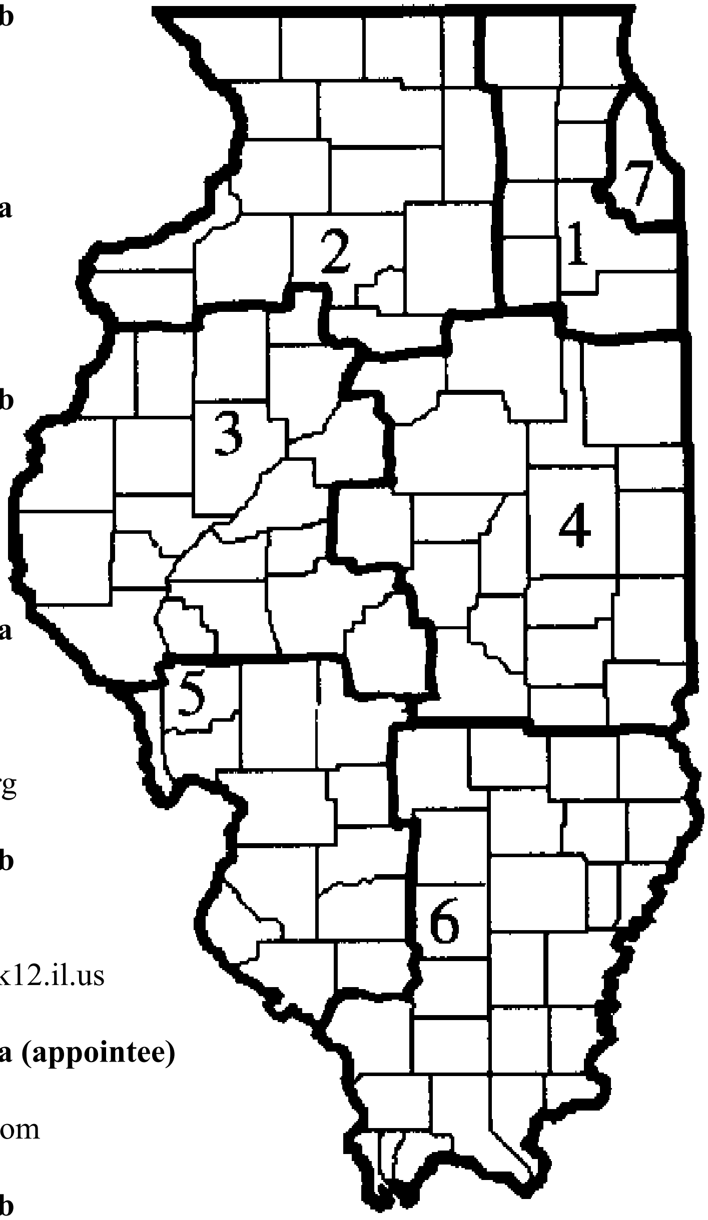

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According to ISTA bylaws, regional directors may serve only two consecutive terms. Directors noted with an "a" are in the first of a two-year term; those noted with a "b" are in the second consecutive two-year term.

Science in the South

November 7 - 8, 2014

Southern Illinois University at Carbondale

See the ISTA website for conference details and registration information.

Luncheon Keynote Speaker:
John Schwegman
Nature Conservationist at the Illinois Department of Natural Resources
"Natural Divisions of Illinois"

ISTA Thanks
Outgoing Regional Directors:
Carol Schnaiter - Region 2
Don Powers - Region 3
Emily Dawson - Region 3
Liz Malik - Region 5
Fred Vallowe - Region 6

ISTA Welcomes
New Regional Directors:
Kristin Rademaker - Region 2
Karen Zuckerman - Region 3
Julie LeMasters - Region 3
Julie Heyen - Region 5
Cindy Birkner - Region 6

NSTA National Conference

Coming to Chicago!

March 12 - 15, 2015

McCormick Place

Want to Volunteer?

Assistance is needed from volunteering at the conference helping attendees, to supervising field trips, stuffing conference bags, and more. Watch for information about signing up to volunteer on the ISTA website. Volunteers may be eligible for waiver or partial waiver of registration fees, depending on the number of hours volunteered.

Local Contacts

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Conference Strands

Natural Resources, Natural Partnerships
Teaching Every Child by Embracing Diversity
The Science of Design: Structure and Function
Student Learning: How Do We Know What They Know?

NSTA 2015

Articles

Reconnecting STEM and ROOTS: Making Chemistry Relevant in Urban Communities

Daniel Morales-Doyle
University of Illinois at Chicago

"Why do we have to learn this?" is a question that many science teachers dread. Early in my career, I did too, especially with topics like stoichiometry or quantum mechanics that were as challenging for students as they were seemingly disconnected from their interests and concerns. As my approach to teaching chemistry has developed over the last decade, this question has become increasingly rare from my students, but it has remained at the center of my curricular planning and my reflections on my teaching.

Science Education for Whom and for What?

Addressing the issue of curricular relevance and the question of why students should learn a particular skill or concept requires an explicit consideration of the purposes of science education alongside an examination of the particular context of our students and our schools. The tension between preparing students for STEM pathways and helping students develop scientific literacy (however defined) is familiar to all high school science teachers. Aikenhead (2006) refers to this tension as a struggle between those who support the pipeline approach and those who support a humanistic approach to science education. The pipeline approach, which Aikenhead argues has always dominated North American

The STEM pipeline has historically been shut off by structural racism for African American and Latina/o students.

science education, prioritizes the preparation of science professionals (including scientists, engineers, and doctors) at the expense of other possible goals. He makes a comprehensive case for a humanistic approach in which students learn science for their everyday life. Aikenhead acknowledges that students who wish to pursue a STEM path should have opportunities to do so. But he argues that, in any context, forcing students to learn science as if they will one day become scientists alienates the vast majority. While the tension between pipeline and humanistic science education is familiar to all high school science teachers, the character of this tension varies widely across different contexts. The STEM pipeline has historically been shut off by structural racism for African American and Latina/o students. This means that pipeline education is a different undertaking in the Chicago Public Schools, where 42% of the stu-

The pipeline approach, which Aikenhead argues has always dominated North American science education, prioritizes the preparation of science professionals (including scientists, engineers, and doctors) at the expense of other possible goals.

dents are African American and 44% of the students are Latina/o, than it is in communities that have more access to the STEM pipeline. Unfortunately, besides limited opportunities in STEM fields and chronic and persistent inequality in funding and resources, the education of African American and Latina/o students in US schools has also been accurately characterized as miseducation (Woodson, 1933/2006), subtractive schooling (Valenzuela, 1999), and deculturization (Spring, 2003). While all of these terms have deep and varied meanings, the overarching theme is that for African American and Latina/o students, schooling has, more often than not, contributed to oppression rather than serving as the great equalizer that many imagine public education to be. Despite claims of objectivity, school science has contributed to this function of schooling (Brown & Mutegi, 2010; Gill & Levidow, 1987). In this context, it becomes clear that humanistic science education, geared towards students' everyday lives, will also be drastically different based on the differences in what life is like in different communities. For example, in the Chicago Public Schools, where 87% of students come from low-income households, struggling to make ends meet is likely to be a significant part of many high school students' everyday life. For our African American and Latina/o students, being racially profiled by police, coping with the ramifications of gun violence, struggling with immigration issues, and dealing with illnesses likely caused or exacerbated by industrial pollution are also often part of their everyday lives. Educators and education researchers argue that science education must address these profound inequities in students' circumstances (Calabrese Barton, 2003). People directly harmed by these inequities have no choice but to address them. For the last seven years, I have taught at a school that is a reality because the school's community did exactly that. After years of advocating for a new high school to alleviate severe overcrowding at the neighborhood school, fourteen community members waged a 19-day hunger strike to force the district to build the campus where the Greater Lawndale/Little Village School for Social Justice (SoJo for short) is located. SoJo is a neighborhood high school with a student population that is about 90% of Mexican descent and 10% African American. Therefore, I consider it part of my responsibility to the community to continue to address injustice through my science curriculum. It is within this context that my colleagues and I deal with the tensions between pipeline and humanistic approaches to science education.

Growing a Program that Nurtures Both ROOTS and STEM

Critical pedagogy is a tradition that begins with the concrete concerns and experiences of the students and, through study and dialogue, supports students in understanding their reality in order to transform it. The ultimate goal of critical pedagogy is that students and teachers struggle together to eliminate the oppressive conditions that create unequal conditions like those described above. Most people trace the roots of critical pedagogy to the work of Brazilian educator Paulo Freire. Recently, science educators have applied Freire's work to develop frameworks for critical pedagogy in science education (Dimick, 2012; Dos Santos, 2009; Mutegi, 2011). Frameworks like these are an important starting point, but as critical pedagogues Duncan-Andrade and Morrell (2008) lament, it is often difficult to turn them into concrete classroom practices.

They argue that "there must be a programmatic vision and it must be something that students can believe in; it must provide hope and a sense that their investment will be rewarded" (p. 71).

Our primary goal as a science department is that our students are able to use the knowledge and skills that they build in our classes to intervene in their lives and communities. We believe that this intervention must occur both through the STEM pipeline and in their everyday lives. Our students' lives are often difficult, so there is urgency to build knowledge and skills that can immediately improve the conditions in which they live. At the same time, we envision some of our students matriculating through the STEM pipeline to become the doctors, engineers, environmental activists, and science teachers that our communities need to be healthy and self-determined. We seek to avoid the typical barriers to this pipeline by employing culturally relevant teaching methods, designing highly engaging introductory courses, and opening our advanced courses to all students who want to take them.

Students' experiences with school science before they reach us are often negative, extremely limited, or both. Even those students who have had positive elementary or middle school science experiences rarely see science as useful in their everyday lives. Our incoming ninth graders need to develop their ability to discuss and critique the culture of Western science and its role in society. Therefore we want all of our students to undergo what we call Restructuring Our Orientation To Science (ROOTS). This acronym is meant as a play on the common acronym STEM and was coined by one of our alumni, while she was taking a senior physics elective. A ROOTS approach to science education involves learning the science content and skills as outlined by the standards, but this learning is explicitly motivated by the need to improve conditions in students' lives and communities. Alongside learning about the successes of Western science, a ROOTS approach aims to develop students' ability to critique Western science as a culture that is not objective and whose impacts are not always positive, despite claims in many textbooks to the contrary. Included in this critique are discussions about how Western science has not only been exclusionary to women and people of color, but has also been used as a tool to justify unequal social relations (Brown & Mutegi, 2010). Rather than tokenizing individual scientists of color as exceptions to the rule of exclusion, students are taught to value the profound contributions to technology and knowledge of nature by non-Western and Indigenous cultures and peoples. Students are also asked to consider the contexts within which scientific progress has been made and to debate both historical and current ethical dilemmas and abuses in science. Some may assume that an approach to science education that involves developing sophisticated critiques of Western science may turn students away from the STEM pipeline. However, we have found the opposite to be true. About half of each of our graduating classes chooses to enroll in Advanced Placement electives in either biology or chemistry, which is a large proportion of students in any school, let alone an urban, neighborhood public school. Many of these students go on to choose STEM majors in college. Most of these students mention the critical approach we take to introductory courses as their reason for enrolling in advanced electives. Thus, our program aims to give all students the opportunity to restructure their orientation to science while encouraging students whose interest runs deeper to pursue opportunities in the STEM pipeline. Ultimately, we believe that knowledge of Western science can inform and positively impact efforts for social change, which must be built from the grassroots. In a society that is totally dependent on technology and wrought with environmental and socio-scientific issues, this means that knowledge and skills that are built in science class will be required to spark, understand, and participate in efforts to organize for social justice. We believe that both our students who choose a STEM pathway and those who do not will potentially play an integral role in such organizing efforts, which hopefully will build into social movements.

This programmatic vision guides curriculum development. The first principle of this curriculum development is that it must start with the immediate interests or concerns of our students or their communities. For Freire (1970/2001), curriculum development begins with generative themes that are identified by a process where educators and community members collaborate to study the reality of the community. Because of the numerous logistical and time constraints that limit us as teachers, we have never been able to engage in a formal study of reality in preparation for developing curriculum. We have also struggled to find themes and issues that speak to our students while also providing a legitimate context within which to teach science. However, by keeping our eyes, ears, and minds constantly open to our students' interests and concerns, we have pieced together curriculum that we believe is relevant to students while also supporting the goals of providing students with access to the STEM pipeline and providing students with opportunities to develop scientific literacy for their everyday lives. In the remainder of this article, I describe the process by which one piece of my chemistry curriculum emerged within this programmatic vision.

During my first few years of teaching in Chicago, I noticed that students would often miss an entire day of school for a doctor's appointment. While I had a few students who I knew had serious ongoing health issues, I did not understand why student athletes would miss an entire day of school for their sports physical or why a healthy student would miss an entire day for vaccinations. Then one winter break, I came down with what I thought might be strep throat. I lived near the school where I taught, so I made an appointment at a local clinic where many of my students went. Even with an appointment and a good health insurance plan, I spent almost an entire day in a crowded waiting room. When I did get to see the doctor, he became upset when I asked him several innocuous questions. After debriefing with my students, I learned that this experience was typical for them. In addition, many students who are the children of recent Mexican immigrants miss class not only for their own appointments, but also to accompany a parent or other relative in order to serve as a translator between their relative and the doctor. Feeling insecure about asking questions of the doctors, many students ask me questions after these appointments because they perceive me as the most approachable science expert in their life.

This scenario illustrates the need for improved access to health care in low-income urban communities and the potential role of both pipeline and humanistic approaches to science education in addressing this problem. Over the years, dozens of students have shared their aspirations to become doctors, nurses, or other medical professionals in order to address this problem. Students are sensitive to the need for medical professionals who understand the needs of the community and who can communicate with their family members in linguistically and culturally appropriate ways. On the other hand, students have an immediate need to improve their interactions between themselves, family members, and medical professionals.

Curricular Examples

It is from this context that a unit for my tenth grade chemistry class called Pills and Bills emerged. To be consistent with our programmatic vision, I also developed a corresponding unit for the elective AP chemistry class that I teach to juniors and seniors. The Pills and Bills unit is built around the central question: Who can we trust to heal us? The unit uses the concept of dosing to build students' conceptual understanding and computational and experimental skills with respect to measuring chemicals. It is through this concept that we help students to become comfortable with the concept of a mole and the correspondence between macroscopic measurements and ratios of individual atoms and molecules. Learning is motivated and contextualized by an ongoing examination of the process of drug development, risk/benefit analysis with respect to side effects, clinical trials, and ethics that builds on other pieces of our curriculum in ninth grade biology. For example, students debate the ethics of the first clinical trials of the oral contraceptive in Puerto Rico, which some have hailed as a major precursor to women's liberation while others, including most of my students, have criticized it for relying on racist stereotypes and exploiting the Puerto Rican women who participated. Students also learn to calculate molar masses in the context of drug testing using mass spectrometry as they debate the ethics of drug testing in the realms of sports, employment, school, and social support programs. While exploring the concept of concentration, students consider the indigenous roots of many modern pharmaceuticals and the different approaches taken by Western and non-Western forms of medicine. Space does not permit a detailed description of all of the learning activities in this unit, but the two-part final assessment captures the thrust of the unit. In the first part of the assessment, students are asked to consider whether the Bayer company should be trusted to produce reliable medications, given that they have never been held accountable for their dubious invention, heroin. Students provide evidence-based answers to this question based on several trials of a titration (with sodium hydroxide solution) of Bayer aspirin pills dissolved in an ethanol solution. Pairs and trios of students are given differentiated levels of scaffolding to design, carry out, and perform the experiment and calculations necessary to make this evaluation. Ultimately, most students find that the pills, which are listed as containing 325 mg of aspirin, are accurately labeled and they make various arguments based on this finding.

In the second part of the assessment, students are asked to come up with a list of questions that they will ask their doctor or pharmacist the next time they or a family member are given a prescription. These lists are shared, combined, and refined in small groups. Then each small group shares their questions with the class and, as a whole class, we combine and refine the list to about ten questions that are likely to be pertinent in many situations. All of the students receive a copy of this list and are encouraged to bring it with them the next time they go to the doctor or pharmacist. This practice is intended to encourage students to feel more comfortable interacting with medical professionals as informed and educated health care consumers. Through the Pills and Bills unit's instruction and assessment, students build knowledge and skills that are aligned with our ROOTS approach to science education. For example, they are able to immediately improve their interactions with our health care system, value their African and Indigenous American ancestors' contributions to modern medicine, and learn to ask critical questions about the multi-billion dollar pharmaceutical industry. But students are also prepared for future success along the STEM pipeline because they have the opportunity to build and demonstrate mastery of science and math standards that prepare them for success in future science classes. A weakness of the unit is that students are not given opportunities to work for larger systemic changes to our health care system. There are reasons why we have chosen to structure the curriculum this way, but this discussion is beyond the scope of this article.

Units like Pills and Bills inspire about 30% of each graduating class at our school to enroll in AP chemistry as juniors or seniors. Many of these students express interest in pursuing a STEM-related major or career. In my AP chemistry classes, students revisit the themes of this unit with more advanced chemistry content. This mini-unit, which I usually teach after the AP exam, opens with a clip from a speech given by Bolivian president Evo Morales to the United Nations. In this speech, President Morales (2009) asks for the overturn of the long standing classification of coca leaves, which are important to Indigenous Andean cultures, as a controlled narcotic substance. This video is used as a re-introduction to a discussion about the use of indigenous knowledge of plants in the development of modern pharmaceuticals. We discuss the imbalance in popular media and opinions with respect to the credit given for problems solved by sanctioned pharmaceutical drugs versus the blame given for the problems caused by illegal street drugs. Many students note that they are stereotyped, as Latinos and people of African descent, as being involved with illegal drug trafficking. Specifically they note that young men

Figure 1: AP Chemistry students analyzing soil samples at Northwestern University.

of color are often characterized as drug dealers and that Mexico, among other Latin American countries, is often blamed for the influx of illegal drugs to the US. This appears especially contradictory to students once they learn that drugs like heroin and cocaine were developed from their less harmful plant sources by European chemists. On the other hand, students note that their African or Indigenous American ancestors are never credited with developing the knowledge of plants that is the basis for many modern pharmaceuticals. Moving beyond a discussion of popular discourse, we consider the economic implications of this discussion. The Bayer corporation continues to rake in huge profits each year selling aspirin, among other pharmaceuticals and pesticides, while they have never financially intervened to mitigate the decades of devastation wreaked by their invention, heroin. Meanwhile, Latino and African American men are greatly overrepresented among the vast numbers of people imprisoned as part of the US war on drugs (Mauer, 2011). This discussion is supported by a series of readings focused on the synthesis and development of aspirin, heroin, and other modern pharmaceuticals. In the final article, from *Science*, the author evaluates the validity of herbal medicines that were the subject of highly organized and catalogued experiments conducted by Aztec scientists before the Spanish colonization of Mexico (Ortiz de Montellano, 1975). After this initial discussion and series of readings, students turn to the laboratory to extract salicin from willow bark to produce salicylic acid. Then they perform an experiment that is common in college organic chemistry classes, the synthesis, purification, and analysis of aspirin (acetylsalicylic acid) from salicylic acid and acetic anhydride. In their lab reports on this experiment, students have shown an exceptional ability to accurately describe and analyze their synthesis of aspirin while also using the introduction to contextualize this experiment with some of the themes about indigenous medicine that are raised in our readings and discussions. Several students have shared that our curriculum crystallized their desire to pursue a STEM career by linking their pursuits in science with their own ancestral traditions and with their communities' current and specific concerns. This contrasts typical approaches that assume all scientific knowledge is an outgrowth of the European enlightenment and that scientific advances benefit all members of society. In conclusion, I present these examples from our curriculum to illustrate our ROOTS and STEM approach to dealing with the tensions between pipeline and humanistic science education in an urban public school. However, our programmatic approach necessarily extends beyond units like those described here. For example, students in my AP chemistry class recently took a trip to Northwestern University's undergraduate chemistry labs to analyze soil samples from the neighborhood for lead and mercury contamination left behind by recently shuttered coal power plants (see Figure 1). Just as creating opportunities for all students to use their content knowledge to improve their lives is an important part of our ROOTS approach, creating opportunities for students to engage in authentic science and to imagine themselves as community-oriented scientists is an important part of our STEM pipeline approach. Also, I do not present these curricular examples as ideals to be reenacted in other contexts. Ultimately my hope is that this description of our approach to science curriculum will inspire others to develop or share their own approaches that support the young people who ultimately change our city, state, and society for the better. I envision science education where the answer to, "Why do we have to learn this?" is always because it will help us improve our lives and communities while making the world a more just and sustainable place.

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2014 Illinois Science Trade Book Annual Reading List (IL-STAR): Reading With Context

Joyce Gulley[1], Jeff Thomas[1], and Jean Mendoza[2]

[1]University of Southern Indiana, [2]University of Illinois at Urbana-Champaign

The 2014 Illinois Science Trade Book Annual Reading List (IL-STAR) has some amazing resources. The criteria and process to identify books has been previously described (Author, 2013). The selections meet the following criteria.

- The book has substantial science content;
- Information is clear, accurate, and up to date;
- Theories and facts are clearly distinguished;
- Facts are not oversimplified to the point where the information is misleading;
- Generalizations are supported by facts and significant facts are not omitted;
- Books are free of gender, ethnic, and socioeconomic bias;
- Information can be connected to an Illinois connect to an Illinois Goal 12 concept/standard statements for early elementary (primary) and late elementary (intermediate);
- Books are readily available in public libraries or bookstores; and
- Books have received at least one positive review in one of the identified professional journals: Booklist, Bulletin of the Center for Children's Books, Horn Book, Kirkus Reviews, Publishers Weekly, School Library Journal, and Science and Children (NSTA).

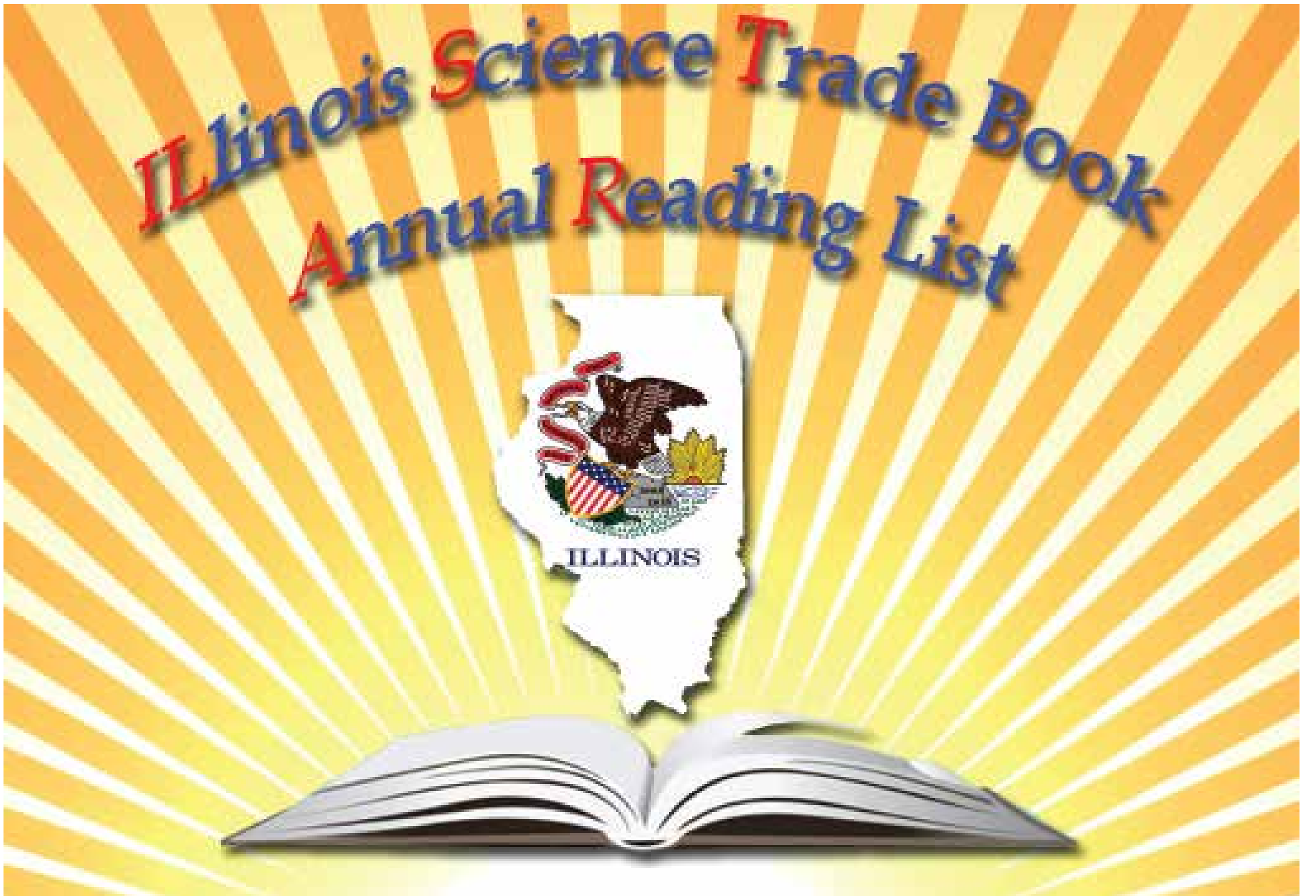
This year's list has books that teachers will be able to use across grade levels and in a variety of teaching and learning exercises. Highlights from this year's list include the following summaries.

Most Illinois children have never seen a bear in the wild, but they have something in common with those awe-inspiring mammals: they get hungry. In *Eat Like a Bear,* author April Pulley Sayre and illustrator Steve Jenkins work together again, and as they did with *Vulture View*, to reveal the lives of animals through the creatures' efforts to find food. The vocabulary is relatively simple but the writing is both poetic and factual; the cut-paper collages are lively and appealing. The material is well-sourced. The book ends with additional information about brown bears.

Even five-year-olds (with some adult preparation) may relate to Jennifer Berne's *On a Beam of Light: A Story of Albert Einstein.* The conversational narrative and Vladimir Radunsky's quirky but charming illustrations convey the wonder experienced by the boy (and the man) whose name would become synonymous with "genius." The book invites children to see that they have their own important, burning questions about the world - and the capacity to pursue answers. The book ends with a bibliography, additional biographical information, and an end-paper gallery of Einstein's favorite things, including his "saggy-baggy sweater."

"Recreating dinosaurs is like putting together a three-dimensional jigsaw puzzle - with plenty of pieces missing," Catherine Thimmesh explains in *Scaly Spotted Feathered Frilled: How Do We Know What Dinosaurs Really Looked Like?* She describes how paleo-artists work from the findings and theories of paleoscientists to visualize fossil remains as living things. Dramatic illustrations by a variety of artists are paired with engaging descriptions of fossil discoveries, showing how artists' interpretations change as paleoscience advances. Readers also see how paleo-artists' work can influence what non-scientists understand about prehistoric life. The text's vocabulary and complexity are right for stronger readers; younger dino enthusiasts may need adult help.

Students will be mesmerized by the tenacity of dolphins and the rescuers who saved them in *Eight Dolphins of Katrina: A True Tale of Survival*, written by Janet Wyman Coleman and



illustrated by Yan Nascimbene. When Hurricane Katrina destroyed an oceanarium in Mississippi, eight tame dolphins were swept into the Gulf of Mexico. Since these dolphins had been raised in captivity, they would be unable to survive in the wild. Readers will cheer at the happy ending and will learn more about these fascinating creatures through a scrapbook of photographs and additional resource notes which accompany the text.

Look Up! written by Robert Burleigh and illustrated by Raúl Colón, will not only have students looking at the stars, but it will also inspire them to follow their passions. Henrietta Leavitt lived at a time when women were discouraged from pursuing careers in science and mathematics and when they did, male colleagues often dismissed them. Such is the case of this pioneering astronomer who refused to give up and is now credited with making a discovery that changed how we measure distance in space.

The universe will open up for readers when they discover *Beyond Our Solar System: Exploring Galaxies, Black Holes, Alien Planets, and More.* Author May Kay Carson presents a brief history of astronomy, biographies of some famous astronomers, twenty-one hands-on experiments to reinforce the concepts discussed, and suggestions for further study.

Nominations for the 2015 IL-STAR list are welcomed. The authors hope that teachers and students enjoy all of this year's selections.

The 2014 Illinois Science Trade Book Annual Reading List

Primary Grade Level IL-STAR Selections

Eat Like a Bear. 2013. April Pulley Sayre. Illus. Steve Jenkins. Henry Holt and Company. 32 pp. ISBN-13: 9780805090390. Cut-paper illustrations and a series of short poems (with some engaging repetition) take young readers/listeners through the seasons with a hungry brown bear, looking for things to eat. Goal 12A. Know and apply concepts that explain how living things function, adapt and change. Goal 12B. Know and apply concepts that describe how living things

The authors hope that teachers and students enjoy all of this year's selections!

interact with each other and with their environment.

Stripes of All Types. 2013. Susan Stockdale. Illus. Susan Stockdale. Peachtree. 32 pp. ISBN-13: 9781561456956. Brief, informative, rhymes accompany bright paintings of notable striped creatures, several of which may be familiar to Illinois kindergartners. The final pages provide details about each of the species depicted, along with a matching game. Goal 12B. Know and apply concepts that describe how living things interact with each other and with their environment.

On a Beam of Light: A Story of Albert Einstein. 2013. Jennifer Berne. Illus. Vladimir Radunsky. Chronicle Books. 56 pp. ISBN-13: 9780811872355. In addition to carefully selected, child-friendly information about Einstein's childhood and his life's work, the book gives a basic explanation of atoms. Goal 12F. Know and apply concepts that explain the composition and structure of the universe and Earth's place in it.

The Animal Book: A Collection of the Fastest, Fiercest, Toughest, Cleverest, Shyest-and Most Surprising-Animals on Earth. 2013. Steve Jenkins. Illus. Steve Jenkins. Houghton Mifflin Harcourt. 208 pp. ISBN-13: 9780547557991. Earth's life forms are amazing, and this book proves it, with expressive cut-paper illustrations, easy-to-grasp infographics, and straightforward writing. This book is useful as a reference and for browsing. Goal 12A. Know and apply concepts that explain how living things function, adapt and change. Goal 12B. Know and apply concepts that describe how living things interact with each other and with their environment.

No Monkeys, No Chocolate. 2013. Melissa Stewart & Allen Young. Illus. Nicole Wong. Charlesbridge. ISBN-13: 9781580592872. 32 pp. The plant and animal interconnections that make it possible for us to have chocolate are revealed in appealing illustrations and lively descriptive text (with humorous asides by a pair of "bookworms"). Goal 12B. Know and apply concepts that describe how living things interact with each other and with their environment.

How the Meteorite Got to the Museum. 2013. Jessie Hartland. Blue Apple Books. 40 pp. ISBN-10: 1609052528. A scientist's work can take place outside the laboratory, as children can see in this true story of what occurred when a meteorite crashed into a car in New York in 1992. The illustrations are humorous and the storytelling clear and conversational. The final pages provide interesting facts about meteorites. Goal 12F. Know and apply concepts that explain the composition and structure of the universe and Earth's place in it.

Parrots Over Puerto Rico. 2013. Cindy Trumbore and Susan L. Roth. Illus. Susan L. Roth. Lee & Low Books. 48 pp. ISBN-13: 9781620140048 Puerto Rico's native parrots, among the most endangered birds in the world, are the focus of efforts by scientists and citizens determined to save the species. In this 2014 Sibert Medal winner, remarkable collages and clear text link the story of these once-abundant birds to the history of humans on the island. Photos and facts at the end of the book further describe the work of saving the parrots. Goal 12B. Know and apply concepts that describe how living things interact with each other and with their environment.

Scaly Spotted Feathered Frilled. 2013. Catherine Thimmesh. Illus. John Sibbick, Greg Paul, Mark Hallett, Tyler Keillor, Stephen Czerkas, Sylvia Czerkas. Houghton Mifflin Harcourt. 64 pp. ISBN-13: 9780547991344. Engaging text and a variety of works by paleoartists show how artists' depictions of dinosaurs have evolved with new understandings from paleontology. Goal 12A. Know and apply concepts that explain how living things function, adapt and change.

Primary Grade Level Honorable Mention Selections

The Deer Watch. 2013. Pat Lowery Collins. Illus. David Slonim. Candlewick Press.

32 pp. ISBN-13: 9780763648909. Painterly illustrations and figurative language capture the experience of an elementary-age boy who goes on a walk with his father to look for deer. The narrator's struggle to observe carefully and patiently will resonate with children, as will his sense of wonder. Goal 12B. Know and apply concepts that describe how living things interact with each other and with their environment.

Lifetime: The Amazing Numbers in Animal Lives. 2013. Lola M. Schaefer. Illus. Christopher Silas Neal. Chronicle Books. 40 pp. ISBN-13: 9781452107141. How much does one animal do in its lifetime? Spare text and illustrations lead readers from a spider's single egg sac to 1,000 baby seahorses. The book ends with facts about each species depicted and an explanation of the author's approach to animal/number problems. Goal 12B. Know and apply concepts that describe how living things interact with each other and with their environment.

Things That Float and Things That Don't. 2013. David A. Adler. Illus. Anna Raff. Holiday House. 32 pp. ISBN-13: 9780823428625. The pictures tell an amusing back-story while Adler describes sink and float experiments and explains density. Goal 12C. Know and apply concepts that describe properties of matter and energy and the interactions between them.

Intermediate Grade Level IL-STAR Selections

Eight Dolphins of Katrina: A True Tale of Survival. 2013. Janet Wyman Coleman. Illus. Yan Nascimbene. Houghton Mifflin. 40 pp. ISBN-10: 054771923X. When Hurricane Katrina destroyed the Marine Life Oceanarium in Gulfport, Mississippi, eight tame dolphins were set free in the Gulf. This is the account of how their determined and inventive trainers found and rescued them. Goal 12B. Know and apply concepts that describe how living things interact with each other and with their environment.

Volcano Rising. 2013. Elizabeth Rusch. Illus. Susan Swan. Charlesbridge. 32pp. ISBN-10: 1580894089. Two levels of text describe the destructive side of volcanos as well as their power to transform landscapes. End notes extend the learning opportunities. Goal 12E. Know and apply concepts that describe the features and processes of the Earth and its resources.

Look Up: Henrietta Leavitt, Pioneering Woman Astronomer. 2013. Robert Burleigh. Illus. Raúl Colón. Simon & Schuster. 32 pp. ISBN-10: 1416958193. As a female astronomer in the late 1800's, Henrietta Leavitt was largely disregarded as a real scientist until she made a discovery that would forever change the way we look at the universe. Goal 12F. Know and apply concepts that explain the composition and structure of the universe and Earth's place in it.

Pluto's Secret: An Icy World's Tale of Discovery. 2013. Margaret A. Weitekamp and David DeVokrin. Illus. Diane Kidd. Abrams. 40pp. ISBN-10: 1419704230. The redefining of Pluto's status is explained in straightforward terms. End notes with photographs and additional resources extend the content. Goal 12F. Know and apply concepts that explain the composition and structure of the universe and Earth's place in it.

Electrical Wizard: How Nikola Tesla Lit Up the World. 2013. Elizabeth Rusch. Illus. Oliver Dominguez. Candlewick Press. 40pp. ISBN-10: 0763658553. In addition to biographical information about Nikola Tesla, this book explains the differences between AC and DC power. Detailed endnotes include additional resources, scientific explanations, and a biographical sketch of Telsa's rival, Thomas Edison. Goal 12C. Know and apply concepts that describe properties of matter and energy and the interactions between them.

Beyond the Solar System: Exploring Galaxies, Black Holes, Alien Planets, and More. Mary Kay Carson. Chicago Review Press. 144 pp. ISBN-10: 1613745443. The history of astronomy is showcased through timeline, diagrams, photographs, suggested experiments, and biographical sketches of the scientists who helped us understand our universe. Goal 12F. Know and apply concepts that explain the composition and structure of the universe and Earth's place in it.

Intermediate Grade Level Honorable Mention Selections

Eruption! Volcanoes and the Science of Saving Lives. 2013. Elizabeth Rusch. Illus. Tom Uhlman.

Houghton Mifflin. 80pp. ISBN-10: 0547503504. Readers learn how volcanologists predict eruptions and work to save the lives of people who are caught in their paths. Goal 12E. Know and apply concepts that describe the features and processes of the Earth and its resources.

Fun Food Inventions: Awesome Inventions You Use Every Day. 2013. Nadia Higgins. Lerner Books. 32pp. ISBN-10: 1467710911. The technology behind everyday inventions, such as microwave popcorn, bubblegum, and popsicles, is described. An afterword provides additional resources and a glossary of terms. Goal 12C. Know and apply concepts that describe properties of matter and energy and the interactions between them.

Seymour Simon's Extreme Oceans. 2013. Seymour Simon. Chronicle Books. ISBN-10: 1452108331. Budding ecologists and oceanographers will learn about various extremes of ocean life, from the impact of violent storms, to the effects of climate change, to the habits of the largest and most dangerous marine animals. Goal 12E. Know and apply concepts that describe the features and processes of the Earth and its resources.

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Author Information

Joyce Gulley, Associate Professor of Teacher Education, focuses on literacy in the elementary grades. She works with future and current teachers to identify high quality materials to use in their classrooms that promote literacy and student engagement with text.

Jeff Thomas, Associate Professor of Teacher Education, focuses on inquiry-based science in the elementary grades. He works with future and current teachers in developing the science process skills and integrating Web 2.0 tools.

Jean Mendoza creates resources for educators and parents on issues related to the education and well-being of young children. A former classroom teacher, she presents professional development workshops on the Project Approach, nature education for young children, and uses of good quality trade books to support children's inquiry.

Scientists in the Classroom

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Being an educator in the twenty-first century is exciting, stimulating, fun, challenging, and dynamic - with a great emphasis on the challenging and dynamic. The scope and depth of the materials we teach, or can teach, to our students is overwhelming and increasing exponentially every year. The list of challenges for science educators is formidable. We have found that one logical piece of the puzzle to help address these challenges is for educators to invite practicing and real-world researchers, engineers, doctors, business owners, and other STEM (science, technology, engineering, mathematics) professionals into the classroom, or take students on field trips to businesses and industries. These scientists in the classroom do not come as mere guest speakers, as an add-on or afterthought, and are not meant to be an interesting diversion from the normal schedule and curriculum. Quite the opposite, the explicit purpose for their presence is to assist and support the teacher, and to present, teach, and discuss discrete, focused, and curriculum-related lessons and topics.

Gains for Students

How will having scientists in the classroom help our students? Most importantly, they can provide real-world and in-the-field examples and applications of information, technology, and methods. They present a new and different face to the students, giving a different perspective on the material, by someone with credentials, experience, and credibility in that particular field. They help connect what the students are learning in the classroom to the real world - a professional face, a real job, and a real application of their learning. The students can address their own questions and interests to the scientist, learning from their experiences, with the teacher acting as a guide and moderator. Students become excited and energized to new areas and potential career pathways. The students begin building a network of contacts and connections with the surrounding community, and gain a greater awareness and appreciation of that community, and of the scientific and professional community.

When experts are brought into the classroom, it can be challenging for students to approach and to interact with them. But when those experts pay attention to students, carefully and thoughtfully listening and responding to their questions they blossom. They gain self-confidence in their abilities to interact with professionals, and can learn important real-world skills. When teachers ask questions, they model that it is permissible not to know everything, and students will truly learn that there is no stupid or bad question to ask. This will serve students well as they move into becoming lifelong learners, future decision makers, policy makers, and leaders of our global community.

Having a professional in the classroom can provide your students with cutting-edge information and a novel perspective. It also provides stimulation for your students - the excitement of someone new and different coming to class. We all know as educators that it is important to vary what we do, to change things up a bit, to maintain student interest. Classroom visitors and/or field trips can help motivate your students.

After any visit or experience, we encourage you to have your students hand-write thank you notes to the professional(s) who visited or contributed to their learning experiences. This provides an opportunity for your students to reflect on the experience, as well as providing another one of those value life lessons.

Benefits for Educators

Educators can't be expected to know everything about all topics, and staying current in even a few areas that you are really interested in can be challenging. Your job is to facilitate learning, using a variety of strategies to engage diverse

Table 1: Questions and topics that professionals have addressed with students.

Scientist/Professional	Question/Topic
Engineer	Road and bridge planning and construction
Pet Store Owner	Selection of a class pet
Physician/Cancer Researcher	Comparison of normal and cancerous cells for a unit on cell function and cell organelles
Forest Preserve Naturalist	Biodiversity and local changes in plant and animal diversity due to suburban development
Local Food Growers	Transport and storage of fruits and vegetables
Sports Shoe Store Owner	Testing and design processes for various shoe types

learners with different learning styles and interests. Use guest scientists to bring current topics and knowledge into your classroom. This will help students see the association of what they are learning in your classroom to what is occurring in the real-world Having professionals in the classroom energizes and assists educators, helping in their own professional development, and giving them fresh perspectives they can pass on to all of their students.

Roles for Professionals in Education

There are many roles that professionals can play, at every grade level, to foster student learning. Professionals can provide expertise by simply offering information and answering student questions. They can become more involved by teaching or demonstrating skills. Those who work at interesting and unique facilities can provide tours. They can pose an authentic problem for students to solve and then participate in discussion and critique of student solutions. Some may be able to offer internships and research experiences to older and more advanced students. The role can be as simple as a short classroom discussion to a one-on-one year-long, or more, mentoring experience.

Professionals can provide expertise, either within the context of an authentic problem, or in connection with the regular classroom curriculum. While having a professional actually come into your classroom is ideal, other formats of interaction can also be effective. These formats can include web conferencing, Skype, conference calls, and email. No matter the format of the interaction, it is particularly effective to have the students submit their questions to the professional in advance. That way the students can clarify their questions, and the professional can be prepared to meet their needs. In these interactions students can gain skills in note taking, interviewing, and interactive discussion. Table 1 provides some examples of questions that a professional might help our students address.

Facility tours are another way professionals can share their expertise with students. Student preparation is vital for ensuring that students get the most out of these visits. Often locations that are not usual field trip destinations can provide very enriching experiences for students. Students can participate in all aspects, including writing a letter or email requesting a visit. Prepare your students by having them research the business, industry, or person that they will be visiting. Make sure that they dress appropriately; you want them to represent you and the school well and there may be safety requirements, such as closed toe shoes, at some facilities.

Demonstrating and emphasizing workplace skills are roles that professionals can bring to your students and your classroom. Professionals have both “hard” skills and “soft” skills. For example, an engineer might work with students on using computer-aided design (CAD) software. A utility company can train high school students to conduct an energy audit of their school, and a biotechnology company might train high school students in laboratory techniques for raising mosquito larvae in order to test methods of mosquito control. But they can also help reinforce important life and job skills, such as appropriate communication, proper dress, being on time, and general responsibility. These are abilities that students may not have learned to appreciate yet, and that supervisors require as the basics for someone being a successful employee.

One way to increase student engagement in their learning is to have a professional pose an authentic problem to a class and then give the students feedback on their proposed solutions. Many students find such an approach to be highly motivating because it gives them the feeling that what they do at school really matters to someone in the real world. Table 2 provides some examples of these. They are integrative and real-world issues, and students learn research skills and problem-solving, and can communicate their ideas in various venues, including making an informative pamphlet, producing a visual poster, or giving an oral report.

Providing students with the ability to conduct authentic research is becoming more and more important, especially at the high school level. At IMSA, the Student Inquiry and Research (SIR) program places hundreds of students into businesses, research institutions, and university laboratories each year. This involves hundreds of scientists, researchers, technicians, graduate students, undergrads, post-doctoral fellows, research associates, and so forth. These individuals mentor and advise students on a one-on-one basis so that they can complete a research investigation. This experience is highly valued by the students, as well as by the colleges and universities that they matriculate to. Some of these students will co-author publications and presentations with their advisors, truly giving them real-world research experiences and providing an opportunity for them to contribute to new knowledge. Many other schools in Illinois and around the country and beyond are taking advantage of the willingness of scientists, researchers, businesses, and entrepreneurs to work with interested and motivated students. These experiences are becoming essential for college and work readiness.

Finding Qualified Professionals

How can an educator find interested, willing, and qualified individuals to come to their classroom? Those with the scientific background relevant to critical components of the science curriculum abound in medicine, engineering, business, and technology. The possibilities are truly limited only by imagination and effort, and it is surprising how flattered and excited many people are to be asked to come and help teach. More often than not, no one has simply ever invited them before.

At a parents' night or an open house, let parents know that you are looking for their help and experience, and directly invite them to inform you of their work and expertise. You might even consider using a brief questionnaire. Consider the jobs, education, and experiences of family, friends, and neighbors. What businesses are located in your area? Many members of the local business community are ready and willing to share the knowledge and practical applications of science used in their products and services, things likely familiar and relevant to students.

The staff members of government and community non-profit institutions, such as park districts, water and sewage treatment plants, and animal control units, hospitals, museums, and local businesses and factories are all potential sources of support. Some individuals have a requirement for community outreach; coming into your classroom or interacting with your students

Table 2: Examples of problems that students have worked to provide solutions to for business and industry partners.

Business/Industry	Problem
Ethanol Manufacturer	Feasibility of developing other biofuel sources
Insurance Company	Teenage perspective on texting and driving
Sheriff's Department	Scientifically assessing noise levels
EPA and Landscape Designer	Water conservation
Sand Mining Operation	Environmental recommendations
Concrete Supplier	Road design
Pharmaceutical Company	Dialysis equipment design improvement
Energy Company	Energy audit of the school

in other ways can help them meet that commitment. Investigate the expertise of the faculty and staff members, especially researchers, at local colleges and universities.

Think about what is going on in your local community. Is the local hospital expanding? Is a road being widened or a new water tower being constructed? Has a new business opened recently? The opportunity for individuals involved in changes to speak with students can be a win-win situation for both parties - your students become knowledgeable about a change in the community, and the community leaders can talk discuss and inform your students about the changes and rationale for those changes.

A key factor for success is to make it easy and appealing to the visiting scientists. Find those areas of experience and knowledge they are comfortable with, and be focused and specific in guiding them in what should be covered, targeted to identified concepts and topics within the curriculum, and for which they can provide concrete and relevant connections to the experience of the students. The teacher - you - should be another student in the class, but prepared to help guide the discussion with leading questions students may not ask. As previously stated, you model lifelong learning for your students, which is invaluable.

The scientist/visitors can gain unique ideas from novices that can move their own work forward. They can gain the perspective of students of a specified age, for example, an insurance company desiring to know how to address the issue of texting while driving with teenagers. (It should be obvious to ask teenagers how to solve this problem!) As stated earlier, volunteering to work with students can help scientists and researchers fulfill work or grant requirements for outreach. It provides them with a forum to tell students about potential careers, and to recruit students to their profession. And it can also be used by supervisory individuals as training for their younger colleagues, helping them to interact and work with younger and more novice individuals - a contribution to professional development. Scientists in the classroom can truly be a winning experience for all parties involved.

Part of Standards-Based Instruction

How would scientists in the classroom help teachers and schools fulfill the requirements of both the current Illinois state standards for teaching and for science curriculum, and the newly adopted Next Generation Science Standards, to be implemented in 2016? Goals 13-A and 13-B of the current standards require helping instructing students to "understand the relationships among science, technology and society" by "applying the concepts" and "applying the practices" of science (http://www.isbe.state.il.us/ils/science/pdf/goal13.pdf). That is, what is the actual context and relevance of the science concepts being taught? What is real-world about them? As often-expressed by the students, "Why do I need to learn this?"

Bringing working, practicing scientists, engineers, and others who daily use the mathematics, tools, and technology accepted and necessary to their work will better illustrate, explain, and help form a connection for the students to answer that why question. Hearing real people talk about solving real problems and meeting real goals in an authentic social context, by applying the same concepts students are learning in the classroom, can be one of the best ways for the science to come alive and to motivate students to use their imagination to apply that science to problems and goals they consider important.

Equally, the 2013 version of the Illinois professional teaching standards, which set performance indicators and expectations for all teachers, direct them to teach in such ways as to incorporate students' current life experiences to connect them to future career and work experiences, and to work effectively with parents and other members of the community to develop cooperative partnerships that promote student learning (http://www.isbe.net/rules/archive/pdfs/24ark.pdf).2] Bringing scientists to the classroom is one of the ways of meeting these expectations for the benefit of the students.

Finally, in addition to the other benefits already described, the NGSS greatly increases emphasis on students learning and understanding science practices: the engineering and problem solving process; use of tools and technology of the field relevant to the problem or question; and the methods for collecting, measuring and analyzing data (http://www.nextgenscience.org/next-generation-science-standards). Effective instruction and curriculum to meet the future standards must include concrete, real world, authentic examples and modeling of these practices, and delivering this instruction should include students seeing, hearing and modeling the work of real practitioners of the concepts and ideas being studied.

Discussion

The concept of inviting scientists into the classroom as partners and in support of teachers and education should not be that surprising, and it is not new. Australia has had an "adopt a scientist" program since 2007, called a "new big idea" by Dr. James Peacock, the former chief national scientist. Students create a continuing relationship with scientists to learn about their work, tools, and research methods, and regularly visit with them, Skype or follow one of the scientist's projects (http://www.scientistsinschools.edu.au/index.htm). Science World at TELUS World of Science in British Columbia has created a similar program, Scientists and Innovators in the Schools (SIS), (http://www.scienceworld.ca/sis). Educators can request a scientist to visit K-12 classrooms. And in November 2012, NSTA devoted almost the entire issue of Science Scope, the middle school science journal, to different approaches of community-based science. Stephens wrote about inviting scientists from the community into the classroom to explore the practical applications of science. Science Screen Report (http://www.ssrvideo.com/virtualscientist.html) has the Virtual Scientist Lecture Series; grades 6-12 educators can request an Internet-based, 30 minute scientist visit, which includes a question and answer session. Closer to home, Northwestern University (NU) has the Reach for the Stars program (http://osep.northwestern.edu/projects/reach-for-the-stars). This National Science Foundation grant funded program places NU graduate students into GK-12 science classrooms for about ten to fifteen hours per week. Participating classrooms do need to be in close proximity to NU.

Plenty of examples for utilizing scientists and professionals in the classroom exist, and they are winning experiences for all participants - students, educators, and the professionals themselves. We think that these examples should help you convince your colleagues, department chairs, and principals that scientists in the classroom is a good idea.

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APPENDIX F –Science and Engineering Practices in the NGSS, from Next Generation Science Standards, April, 2013, © 2011, 2012, 2013 Achieve, Inc. Based on A Framework for K-12 Science Education, © 2012, National Academy of Sciences. (http://www.nextgenscience.org/next-generation-science-standards)

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Promoting Conceptual Change of Preservice Teachers Declarative and Configurational Understanding of Biomes Using Animations and Digital Images From Space

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Abstract
Student alternative conceptions in physics and chemistry content have been researched in recent years, but equivalent research in Earth science and physical geography has not been published. This research is important because most alternative conceptions begin in a person's early years and persist into adulthood. In this study, interviews were conducted with preservice elementary teachers to assess prior knowledge and the presence or absence of alternative conceptions. Students' marked locations on a world map that corresponded to biomes, such as desert, rainforest, grassland, and tundra. A pre- and post-graphics-enriched instructional intervention focusing on the use of animations and digital remotely-sensed imagery were used, followed by a second round of sketch mapping. Content analysis on both interviews and student-generated maps were conducted. Spatial and content knowledge, ranging from declarative (prior knowledge) to configurational (knowledge of the relationships between and among locations), was observed among the students who participated in the study. The results of the study indicate that the use of technology-based instruction, including climate maps and satellite imagery, promotes conceptual change. This study has implications for teaching elementary preservice teachers, as well as teaching science and physical geography to undergraduates, from a causal perspective using remotely-sensed imagery.

It is important to identify and correct students' spatial and causal misconceptions because research suggests that they can act as barriers to further learning.

Introduction
Earth system science and geography are essentially integrative disciplines that study the interactions between people and their environments on or near the Earth's surface. Within this tradition of human-environment relationship, geographical literacy demands that all students gain a common knowledge of their immediate and world environments (Natoli and Gritzner, 1988). Specific to this research, preservice elementary teachers, who will need to pass on knowledge concerning both science and geography to children, should have an understanding of the spatial distribution and cause of biomes at the high school level. The main goal of this study was to utilize technology (using variety of graphical representations, including digital images from space) during an instructional unit on biomes in order to bring about conceptual change in students understanding of this concept.

Background Literature
Little research has considered students' (particularly preservice teachers) understanding of biomes and yet this concept is an integrative one that requires complex thinking when considering the standards for instruction. Two Next Generation Science Standards, (National Research

Council, 2012) connect to the development of knowledge regarding biomes:

1. ESS2.D: Weather and Climate

- The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (HS-ESS2-2)
- Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-6),(HS-ESS2-7)
- Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-6)

2. ESS2.E Biogeology

- The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it. (HS-ESS2-7)

And, as Geography for Life (1994) (the national geography education standards) suggests, elementary students should be learning not only the characteristics of biomes, but also about their spatial distribution. The interest in location, patterns, and explanation are tied to this element. Besides understanding of how things are spatially located and distributed, maps play an important role in understanding concepts and retrieving information. Kulhavy's (Kulhavy et al. 1985) conjoint retention theory and Paivio's dual coding theory (1986) both claim that any organized spatial graphic, such as a geographic map, provides the student a visual which s/he can use to acquire and store information (Verdi and Kulhavy, 2002). Furthermore, understanding the distribution of biomes requires certain spatial abilities, including the ability to 1) interpret macro spatial relations; 2) uncover spatial associations within and between regions; and 3) compose distributions, patterns, and arrangements (Self and Golledge 1994). These are key skills in geography.

While students should be learning about biomes and their spatial distribution, there is no guarantee that they are. In fact, we might expect students to hold a number of misconceptions about biomes simply based on the wide body of research about student misconceptions in the sciences in general (see for example, Brody 1994; Halloun & Hestenes, 1995; Leather, 1987; Schoon, 1989, 1992), and in geography specifically. It is important to identify and correct students' spatial and causal misconceptions because research suggests that they can act as barriers to further learning (Ausubel 1968)

Allowing students to analyze imagery and maps and to come to their own conclusions will solidify knowledge far more than a lecture.

Previous research in this area (Acheson & Beilfuss, 2010) yielded interesting results. For instance, less than half (42%) of the sample (n=26) in the pilot study conducted by Acheson et al. (2010) were able to adequately define climate or biomes. Nearly an equal number (38%) of participants equated climate with weather. In this study, undergraduate students were equally unsure about defining biome. Thirty-eight percent stated that they had never heard of the word biome, although they did recognize specific biomes, like desert and rainforest. Studies, such as the work described above, intended to discover or document students' alternative conceptions certainly have a place in the literature. However, a richer area of research would be to, not only recognize that misconceptions exist, but also implement instructional interventions that facilitate conceptual change. This is especially important when considering the education of preservice teachers who will later teach this topic to children in the K-12 setting. Utilizing technology within an instructional intervention allows the learner to view spatial and abstract concepts using a graphical, dynamic representation.

Methodology

In order to understand college students' conceptions about biomes, two primary methods were used. First, interviews were conducted to understand preservice teachers' conceptions about biomes. Second, a cued-sketch mapping task was used to determine students' spatial understanding of these phenomena. This study was designed to measure students' 1) configurational knowledge (knowledge of the associations between and relative locations of places); and 2) declarative knowledge (prior knowledge) of the spatial patterns and areal relationships that help explain biomes (Kitchin, 1997). An instructional intervention was designed utilizing a variety of graphical representations, such as climate mapping and images from space, in order to facilitate conceptual development and conceptual change.

Setting and Participants

Participants volunteered from a pool of preservice teachers taking Elementary Science Methods at a Midwestern university. Most students were juniors and seniors and all were elementary education majors. Students who volunteered to be interviewed were asked the following questions:

- What is climate?
- What is a biome?
- Have you ever heard of the word rainforest? desert? and so forth.
- What does it look like if we could take a trip there?
- What types of animals and plants would you find there?

A rich area of research is to not only recognize that misconceptions exist, but also implement instructional interventions that facilitate conceptual change.

Students' were given the following prompt along with a blank world map: Where is each biome found on the Earth? Mark the biomes below onto the world map using the coloring pencils and the color codes below:

a. Rainforest	Red
b. Temperate or Deciduous Forest	Green
c. Boreal or Taiga Forest	Light green
d. Grassland	Orange
e. Savanna	Brown
f. Desert	Yellow
g. Tundra	Purple

After completing the biome world map, students were asked: Is there a relationship between a biome and its location on the Earth? Why?

After interviewees had discussed their understanding of biomes, they were asked to mark the locations of seven major biomes on an outline world map. Interviews were tape recorded and transcribed. Data was analyzed using standard qualitative techniques (Miles and Huberman 1994) including coding along thematic lines, while maps were scored based on a scoring rubric. Scoring of maps included location accuracy and spatial distribution of biomes.

Student-generated maps, using a provided world outline map, were assessed both pre and post instruction. Students' attitudes about the use of technology were also assessed using an attitude survey. The instructional intervention of using multiple representations of biomes and their spatial distributions was accomplished using a PowerPoint presentation that included satellite imagery, as well as other representations in a graphic form such as climate maps, etc. A within-group review of the instructional graphics, conducted by a geographer and a science educator, occurred prior to the implementation of the study.

Results and Discussion

A pilot study was conducted during the normal class instruction for an elementary science methods course. Prior to instruction, the nineteen students who participated held a wide range of ideas regarding biomes. Some examples are provided below.

Definition of Biome
- Students thought it only pertained to climate
- They also referred to it only as a habitat
- "it's in space"
- Students thought that the climate was controlled as in a biodome
- Students confused biome with biodome (2)
- Location of animals with common characteristics
- Ecosystem
- Land features
- Region of weather conditions
- Plants/vegetation

Climate
- Most students thought climate just dealt with weather as a whole
- "the temperature outside"
- Relative temperature of a region
- "the weather a place usually experiences"
- "average temperature collected over 30 years"
- Students think climate is weather over time

Contents of Biomes
- Students thought Africa was a rainforest climate
- Characterize desert with snakes/lizards and nothing else
- Misconception that desert isn't diverse in plant and animal life
- Rainforest most diverse, desert least diverse

Biome Location
- Students thought it was due to the location of the equator, but ignored mountain ranges, coastlines, and so forth
- Students didn't recognize the importance of land features in forming biomes
- Students thought biome location was determined by access to water and other weather patterns

Pre-instruction Maps - Number of locations marked correctly	Spatial distribution of biomes marked on world maps (%)	Post-instruction Maps - Numbers of locations marked correctly	Spatial distribution of biomes marked on world maps (%)
3	50	8	90
2	15	8	80
3	10	7	95
8	65	12	85
7	55	8	100
6	85	6	90
11	100	12	100
6	85	12	100
6	65	12	100
1	15	6	50
3	50	8	85
5	50	11	100

Table 1. Map scores based on accuracy and spatial distribution of biomes pre and post instruction.

Maps

- Africa was usually made to be all rainforest
- Most of the western US was marked as desert, even Washington State
- Students thought all of Canada was tundra
- The borders of the biomes were off
- All of North America was labeled as deciduous forest
- One student thought there were only three types of biomes

After the pilot study, the PowerPoint presentation was edited to include more images of climate maps and satellite images in order to assist in the clarification of the causes of biomes and their locations on the planet. In addition, we added a computer animation (http://weather.indstate.edu/CDC/ETS/). During the following summer, students who were participating in a summer session of elementary science methods course were asked to volunteer for the study. Pre- and post-maps were collected from twelve students in the course and four interviews were conducted. Table 1 includes the data on students' pre- and post-maps. Maps were scored based on the number of locations that were marked correctly, as well as the percentage of biomes marked on the world map, thereby indicating some knowledge of the spatial distribution of biomes. The students' understanding of both biome location and spatial distribution improved from pre- to post-map sketching.

We were able to use satellite imagery, as well as an animation (http://weather.indstate.edu/CDC/ETS/), to bring about conceptual change in these particular students. Maps produced after instruction included the locations of multiple biomes and the accuracy of those locations increased. Anecdotally, it appears that there was an increase in learning using technology.

Changing Instruction to Combat Misconceptions on Biomes

From the information collected throughout the process of this small study, we were able to identify several key misconceptions that most students possessed. These misconceptions covered a variety of topics but had mainly to do with what a biome actually is, what animals and plants are in each biome, and where each biome is located on the Earth and why. It was surprising to hear how little instruction the students had actually received on this subject in their prior K-12 classroom experiences. These are upper level college students, some of which had no idea what a biome contains. If this is true for college students, then it may be that middle school students' ideas and definitions of biomes are even more misunderstood. After collecting data from the participating students, we were able to identify patterns in their thinking and possibly determine the roots of these misconceptions. This in turn allowed us to develop an instructional guide for teaching the students the cause of biomes.

Satellite imagery was a very important tool in helping the students understand the locations of the biomes and perhaps provide a bigger picture of why the biomes are where they are on the Earth. Maps allowed the students to see the bigger picture of the entire Earth; that way they could make observations such as a certain biome appears to be along the same line of latitude all the way around the Earth, which would lead to further investigation on their part as to why that may be. In order to overcome these misconceptions in the younger, middle school group, we recommend that educators structure a lesson mainly around visual aids. Students of that age group flourish in an environment that has many images for them to observe. There are many activities that could be used to show the students why the position of the Sun and the angle at which it contacts the Earth determines why the biomes are where they are. The Hadley Cell Effect could also be shown using images to explain the evaporation of water

Satellite imagery and animation were used to bring about conceptual change

and its rotation in the atmosphere north and south of the equator which produces deserts at certain lines of latitude that are just north of rainforests for example. Eliminating the misconceptions that students have about biomes simply requires precise instruction using instructional strategies that include multiple representations of the concept being studied. This can be done by showing satellite imagery and locations of the biomes on the Earth. A lesson that would be most effective would be one that is structured around asking the students intelligent questions as opposed to just lecturing. Allowing the students to analyze imagery and maps and coming to their own conclusions will solidify the knowledge far more than a simple lecture. The misconceptions concerning biomes are broad and varied. This provides some difficulty to the instructor in pinpointing certain beliefs. We recommend that educators use some sort of test before the lesson begins to assess the conceptions the students have about biomes so the lesson could be better structured to meet their cognitive needs. The use of maps and satellite imagery in instruction could be an invaluable tool to helping the students understand the cause for specific locations of biomes across the world and the biodiversity of each biome.

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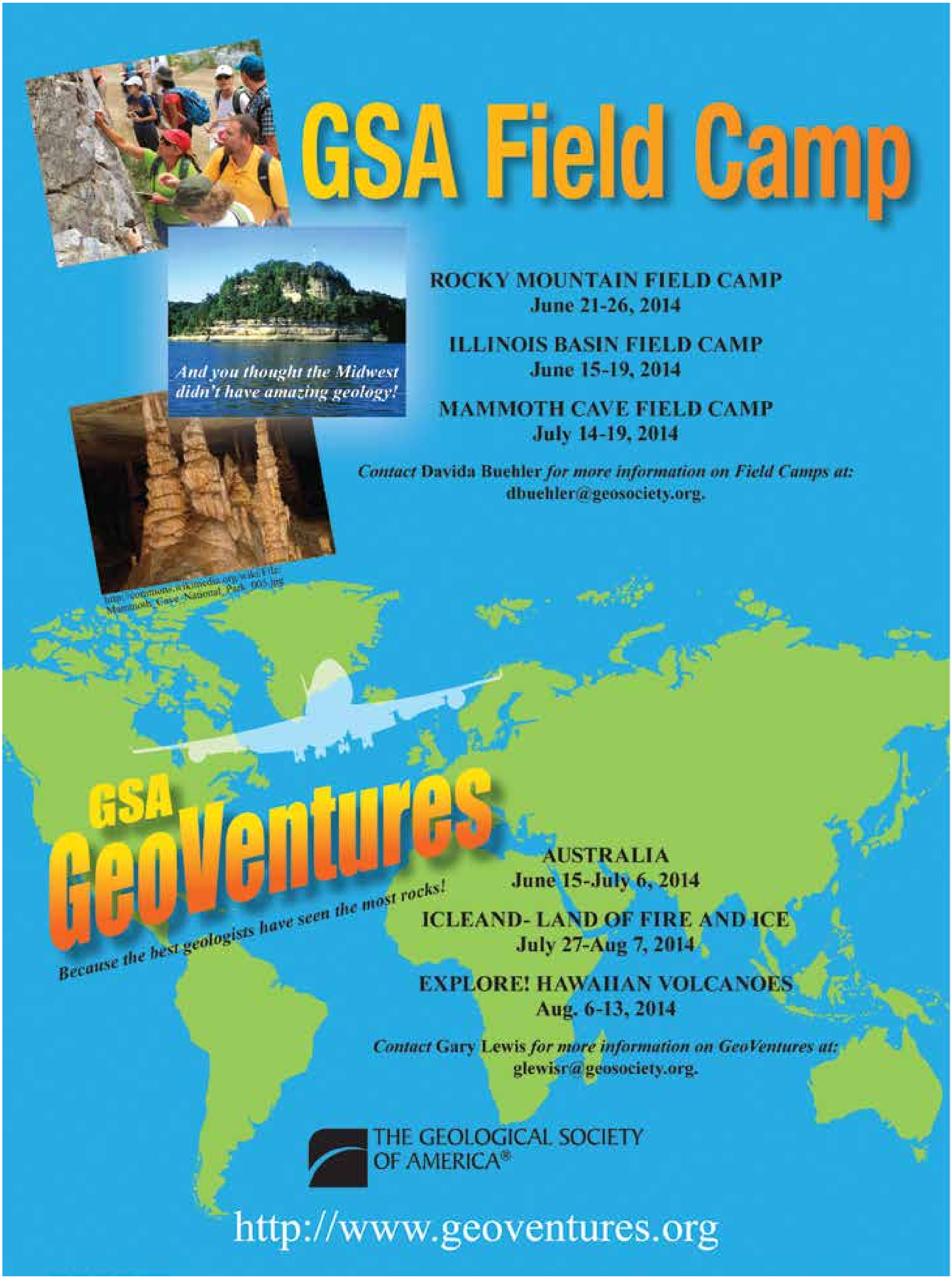
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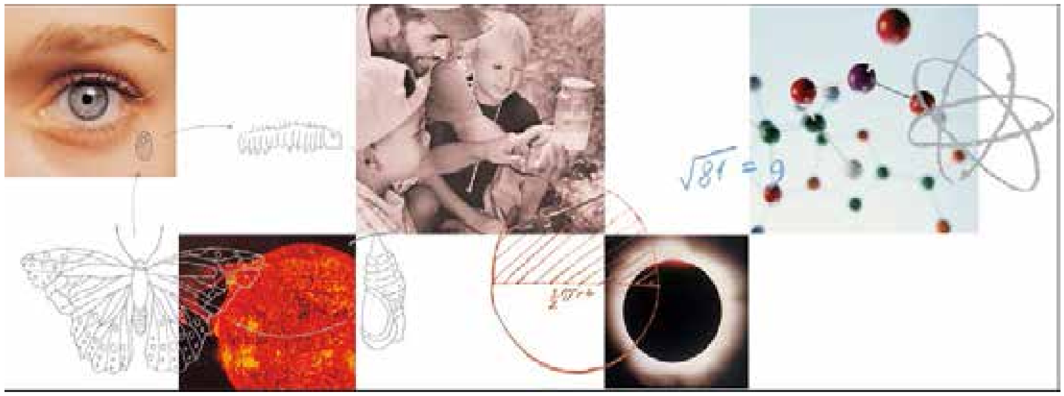

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